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The dynamics of natural gas consumption and GDP in Bangladesh

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ABSTRACT

Reserves of natural gas in Bangladesh are very large and total demand has increased secularly in recent years. This paper examines the causal relationship between the consumption of natural gas and GDP in Bangladesh over the period 1980 to 2010. We find that there is a positive unidirectional causality running from GDP to natural gas consumption: movements in GDP affect the consumption of natural gas but not vice-versa. While our results rest on several statistical assumptions, they support the pursuit of policies that are in line with energy conservation. Implementing these policies will be of particular significance in light of the fact that Bangladesh's current reserves of natural gas will not meet its current level of consumption demand beyond the next two decades.

Contents

1. Introduction

The literature on the relationship between energy consumption and economic growth emerged during the oil shocks of the 1970s [37]. Since the seminal paper by Kraft and Kraft [26], this relationship has been extensively studied by researchers. Their results reveal four main findings on the causal relationship between energy (measured in a variety of ways) consumption and economic growth: (1) unidirectional causality running from energy consumption to economic growth [2,49,48,42], (2) unidirectional causality running from economic growth to energy consumption [26,8,16,9,37], (3) bidirectional causality between energy consumption and economic growth [21,17,20,15,34], and (4) no causality [50,13,35,46].

These findings show that there is no unique policy recommendation that can be applied across all countries when the goal is to advance economic growth through energy policy. For example, energy conservation policy will have minimal to no impact on economic growth when there is no causality between these two variables (*neutrality hypothesis*). However, if unidirectional causality runs from energy consumption to growth then the so-called *growth hypothesis* holds. In such a situation, any reduction in energy consumption may have a deleterious impact on country's economic growth prospects. On the other hand, if causality runs only from GDP growth to energy consumption, then energy conservation policy may be pursued without negatively impacting GDP growth (*conservation hypothesis*). Finally, if there is bidirectional causality, interdependent relationship between energy consumption and growth (*feedback hypothesis*) must be taken into account in the process of formulating policies.

While a plethora of literature examines the association between energy and economic growth, it is necessary to identify

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this relationship at the disaggregated level since different types of energy may have different effects on economic growth [27]. Hence, a new set of literature has recently emerged to study the link between electricity consumption, coal consumption, natural gas consumption, gasoline consumption, and other types of energy consumption and economic growth separately.[1]

Vast reserves of natural gas have been discovered at the Bay of Bengal since the mid-1990s, onshore and offshore. Proven reserves of approximately 15 trillion cubic feet have been found in 22 discovered gas fields (Reuters, 2012). Following from the discovery of these reserves, there has been rising demand for it by the manufacturing and household sectors[2]: consumption of dry natural gas has risen from 50 billion cubic feet in 1980 to approximately 711 billion cubic feet in 2010 [45].

In a published report in 2000, Jaccard et al. [23] argued that proven reserves of natural gas would last for 45 years at the then current rate of natural gas consumption. Additionally, the authors also cautiously mentioned that these reserves would last only about 17 years if the 2000 rate of natural gas use in Bangladesh were to increase only by 10 percent per year. As a matter of fact, the consumption of natural gas has increased by more than 10 percent per year since 2000.[3] Hence, although the total proven reserves have reached 15 trillion cubic feet in recent years, experts calculated that it would take 19 years or so before the recoverable gas reserves are fully exhausted unless new fields are found and explored (Reuters, 2012).

Concomitant with the sharp rise in the consumption of natural gas, Bangladesh has achieved a remarkable average GDP growth rate of 5 percent per year from 1981 to 2010. In fact, since 2004, GDP growth rates have always been at least 6 percent per year [47]. Surprisingly, the literature on the link between economic growth and natural gas consumption in Bangladesh is conspicuously absent. The aim of this paper is to fill this gap by addressing these questions: (1) Does the use of natural gas have any significant impact on the GDP of Bangladesh? (2) What is the causality between natural gas consumption and economic growth in this country? (3) Should policies related to conservation of natural gas be implemented in Bangladesh?

We use data on real GDP and natural gas consumption for Bangladesh from 1980 to 2010. We find that both series are cointegrated in the long run. Additionally, Granger causality results suggest the existence of a unidirectional causality from GDP to natural gas consumption in Bangladesh. The rest of the paper is organized as follows. Section 2 presents the review of relevant literature on natural gas consumption and economic growth. Section 3 discusses the data and econometric method that will be used. Section 4 presents our findings. Section 5 underscores the policy implications and recommendations emerging from our results and Section 6 concludes.

2. Review of the literature

Empirical results on the causal relationship between natural gas consumption and economic growth can be divided into four groups: unidirectional causality from natural gas consumption to GDP, unidirectional causality from GDP to natural gas consumption, bidirectional causality and no causality.

The seminal paper by Yu and Choi [49] is among the first to identify the causal relationship between natural gas consumption and GNP. Applying Sims and Granger causality technique on UK time series data for the post-war period from 1950 to 1976, they find evidence of unidirectional causality running from natural gas consumption to economic growth. Hence, the growth hypothesis seems to be true for the UK. More recently, Yang [48] uses Granger technique on Taiwan's time series data from 1954 to 1997 to identify causal relationships between GDP and the consumption of aggregate as well as different types of energy including coal, oil, natural gas and electricity. Yang's results suggest bidirectional causality between total energy consumption and GDP, but a unidirectional causality from natural gas consumption to GDP. Lee and Chang [28] however argue that Taiwan has experienced a number of changes in the economic structure from 1960 to 1980 including adopting export promotion and financial liberalization policies. Hence, it is important to take structural breaks into consideration. However, even after including the structural break, Lee and Chang find a unidirectional causality running from natural gas consumption to economic growth from 1954 to 2003. These results, therefore, reinforce the findings of Yang [48].

Kum et al. [27] apply the bootstrap-corrected causality test on G-7 countries for the 1970–2008 period for Canada, Germany, Italy, Japan, United Kingdom and United States and 1960–2008 period for France. For Italy, they find that the Granger causality runs from natural gas consumption of GDP growth. Pirlogea and Cicea [38] use a smaller dataset from 1990 to 2010 and find that natural gas consumption causes economic growth in Spain. Within a multivariate framework, Muhammad et al. [32] examine the long run relationship between natural gas and GDP growth in Pakistan from 1972 to 2010. Their results from the ARDL procedure support the natural gas consumption-led-growth hypothesis.

Sari et al. [41] estimate the effects of natural gas consumption on industrial production (as a proxy of economic activity) in the US. Using monthly dataset from 2001 to 2005, they find unidirectional causality from industrial production and employment to natural gas consumption. Payne [36] uses the US data for the 1949 to 2006 period and applies Toda-Yamamoto long run causality test to investigate the natural gas consumption-real GDP nexus. Payne's results support the findings of Sari et al. [41]. A similar result is found by Kum et al. [27] for the UK.

Another strand of the literature finds no causality between natural gas consumption and economic growth. Yu and Choi [49] do not find the evidence of any causal relationship between natural gas consumption and GDP in the United States. Aqeel and Butt [4] examine the causal relationship between gas consumption and GDP for the period of 1955–56 to 1995–96. The novelty of their work is the application of the Hsiao's Granger test. Their results do not suggest any causal relationship between natural gas consumption and GDP in Pakistan. Fatai et al. [12] do not find any evidence of causal link while studying the growth-gas consumption nexus in Australia and New Zealand. The insignificant impact of natural gas consumption on economic growth is also evident in Canada and Japan during 1970–2008 [27] and Romania from 1990 to 2010 [38]. Therefore, implementation of the conservation policy may not have any negative impact on economic activities of these countries where either *conservation hypothesis* or *neutrality hypothesis* holds.

The so-called feedback hypothesis has been found in recent papers by several authors. Zamani [51] uses a vector error-correction model to identify the causal relationship between gas consumption and GDP, industrial and agricultural value added in Iran from 1967 to 2003. The results suggest bidirectional causality between GDP and gas, but a unidirectional causality running from agricultural value added to gas consumption and a unidirectional causality from gas consumption to industrial value added. Therefore, it can be argued that the conversation of natural gas may have no effect on the agricultural output but detrimental effect on the industrial output in Iran. Using quarterly data from 1991 to

[1] See for example, [31,5–7,19,10,14].

[2] In Bangladesh, natural gas is mainly used for thermal power generations, and other commercial and household consumption ([22,30]).

[3] Total consumption of natural gas went up from 342.56 billion cubic feet in 2000 to 710.89 billion cubic feet in 2010. Hence, the rate of increase of total gas consumption per year was approximately 10.75 percent.

Table 1
Summary results on causal relationships between natural gas consumption and output.

Authors	Country/area	Time	Method	Findings
Yu and Choi [49]	UK	1950–1976	Granger causality	NC→Y
	USA			NC≠Y
[48]	Taiwan	1954–1997	Granger causality	NC→Y
Aqeel and Butt [4]	Pakistan	1955–1996	Hsiao Granger causality	NC≠Y
Fatai et al. [12])	Australia	1960–1999	Johansen-Juselius, Toda-Yamamoto, ARDL causality tests	NC≠Y
	New Zealand			
Lee and Chang [28]	Taiwan	1954–2003	Structural break, causality	NC→Y
[51]	Iran	1967–2003	ECM	NC↔Y
				AP→NC
				NC→IP
Sari et al. [41]	USA	2001–2005 (monthly)	ARDL	IP→NC
Pirlogea and Cicea [38]	Romania	1990–2010	Granger causality	NC≠Y
	Spain			NC→Y
Payne [36]	USA	1949–2006	Toda-Yamamoto causality	Y→NC
Kum et al. [27]	Italy	1970–2008	Bootstrap-corrected causality	NC→Y
	UK			Y→NC
	France			NC↔Y
	Germany			NC↔Y
	USA			NC↔Y
	Canada			NC≠Y
	Japan			NC≠Y
Lim and Yoo [29]	Korea	1991–2008 (quarterly)	Granger causality	NC↔Y
Muhammad et al. [32]	Pakistan	1972–2010	ARDL	NC→Y

Notes: (1) →, ↔ and ≠ indicate unidirectional, bidirectional and no causality respectively. (2) NC = consumption of natural gas; Y = GDP; IP = industrial production and AP = agricultural production.

2008, Lim and Yoo [29] find evidence of bidirectional causality between natural gas consumption and economic growth in Korea. Evidence of bidirectional causality has also been found by Kum et al. [27] for France, Germany and the United States. Apergis and Payne [3] use a multivariate panel framework of 67 countries to examine the gas-growth nexus. Their results also support the feedback hypothesis in both the short and long run. Results on causal relationship between natural gas consumption and output are summarized in Table 1.

The existing empirical literature indicates that causal relationship between natural gas consumption and economic growth varies over time within countries and across countries. Hence, it is not possible to make a general policy prescription that can be applied to all countries. Since total reserves of natural gas in Bangladesh may be exhausted any time from next 17 to 45 years, it is imperative to identify the relationship between natural gas consumption and economic growth for this country. This specific concern has inspired us to undertake this study so that policy-makers have a clear idea about possible policy options for this resource-scarce country.

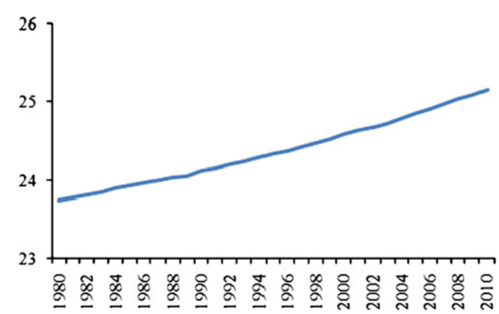


Fig. 1. Log of real GDP.

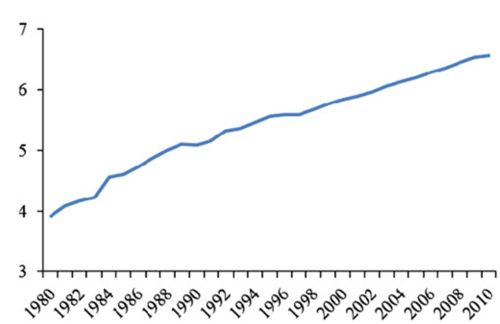


Fig. 2. Log of natural gas consumption.

3. Data and methodology

The annual data on natural gas consumption (cubic feet) in Bangladesh have been collected from the US Energy Information Administration (EIA). This series begins in 1980 and ends in 2010. Therefore, the choice of the starting period is constrained by the availability of data on natural gas consumption. Annual data on real GDP for the same period are collected from the World Development Indicators (WDI). The log of real GDP and the log of the consumption of natural gas are shown in Figs. 1 and 2.

As the figures show, both series have pronounced upward trends. It has widely been discussed that most macroeconomic variables contain unit root, and hence are non-stationary in levels [33]. Since both natural gas consumption and GDP variables in our dataset are defined over a period of 30 years, it is important to identify whether these variables are non-stationary. Empirical time series studies generally use Augmented Dickey-Fuller (ADF) or Phillips-Perron (PP) unit root tests to examine the stationarity of time series variables. However, if economic events cause shifts in regime, results from standard unit root tests are questionable [28]. Hence, we use a different testing procedure proposed by Zivot and Andrews [52], which considers the possible shift in regimes.

This test is similar to the Phillips-Perron test for stationarity but unlike the latter it includes an endogenously determined structural break point. Results from the Zivot-Andrews test are reported in Table 2. It is evident from the results that both GDP

Table 2
Zivot–Andrews unit root test results.

Variable	Levels		First differences	
	t-Statistics	Year of break	*t*-Statistics	Year of break
GDP	−3.58	1997	−7.44***	1990
Gas consumption	−2.03	1988	−6.26***	1987

*** Indicates significance at the 1 percent level.

Table 3
Johansen cointegration test results.

Number of cointegrating equation (r)	Eigen value	Trace statistics (λ_{trace})	Maximum eigen statistics (λ_{trace})
None (H_0: $r=0$)	0.50	28.99**	19.95**
At Most One (H_0: $r\leq 1$)	0.27	9.04	9.04

** Indicates significance at the 5 percent level. The optimal lag length is chosen by using AIC criteria.

Table 4
Results from pairwise Granger causality test using VECM model.

Hypothesis	*F*-Statistics	Probability
Natural gas does not Granger cause GDP	0.08	0.92
GDP does not Granger cause natural gas	5.01**	0.02

** Indicates significance at the 5 percent level.

and gas consumption variables are non-stationary in levels but stationary in first differences. Hence, these variables are integrated of order 1, *I*(1) when structural breaks are taken into consideration.[4]

Since natural gas consumption and GDP variables are non-stationary at levels, but stationary at first differences, we examine whether a linear combination of the two series is in fact stationary. If the linear combination of the two series exhibits a stationary relationship by converging to a long run equilibrium then it can be argued that the two variables are cointegrated. One of the most commonly used cointegration test was proposed by Johansen [24] and Johansen and Juselius [25]. Based on the maximum likelihood method, the objective of this test is to find out the number of cointegrating vectors in the linear system. If the number of cointegrating vector is found to be zero (i.e., $r=0$), then it can be argued that the series of natural gas consumption and GDP do not converge into a long run equilibrium.

The Johansen test for cointegration produces two types of likelihood ratio tests: the trace statistics (λ_{trace}) and maximum eigenvalue (λ_{max}). In this paper, we employ both statistics to test for cointegration. If the two variables are found to be cointegrated in the long run, we will attempt to identify the direction of the causal relationship. If natural gas consumption and GDP are non-stationary (at levels) and cointegrated, then the vector error correction model (VECM) can be utilized for the Granger causality test ([11,18]).

4. Results

Table 3 shows the Johansen cointegration test results. The null hypothesis of zero cointegrating relationship (H_0: $r=0$) is rejected by both λ_{trace} and λ_{max} at the 5 percent level. However, the null hypothesis of the existence of at most one cointegrating relationship (H_0: $r\leq 1$) cannot be rejected even at the 10 percent significance level.

Based on our findings that two series are cointegrated in the long run. We therefore utilize the vector error correction (VECM) model to explore the causal relationship between natural gas consumption and GDP in Bangladesh. Dynamic Granger causality results are presented in Table 4.

From Table 4, we deduce that that there is unidirectional causality running from GDP to natural gas consumption. This result is significant at the 5 percent level. Pairwise Granger test however does not indicate that there is a causal relationship from natural gas consumption to GDP, even at the 10 percent level. Our result is similar as that found by Payne [36] for the US and Kum et al. [27] for the UK. Hence, this result on the relationship between natural gas consumption and GDP support the existence of the conservation hypothesis for Bangladesh.

[4] As our paper is concerned primarily with the casualty between GDP and gas consumption, we do not concern ourselves with explaining the structural break points chosen.

5. Policy implications and recommendations

Our findings suggest a role of output in the consumption of natural gas in Bangladesh. While these findings rest on several statistical assumptions, they reinforce the role of energy conservation in Bangladesh. This has also been suggested by Mozumder and Marathe [31] for electricity and Paul and Uddin [37] for aggregate energy. To conserve the consumption of natural gas, decision-makers need to implement a number of strategies that promotes efficient use of this scarce resource. First, the price of natural gas in Bangladesh should be market-determined. Compared to neighboring South Asian countries, such as India, gas price in Bangladesh is often fixed at a sub-optimal level. Therefore, households pay a subsidized rate which is lower than the market price. This negatively affects energy efficiency by encouraging wasteful use of this resource. To promote optimum utilization of natural gas at the household level, government needs to create an efficient pricing system such as *pay per use* in which the price of natural gas will be determined by the usage.

Second, policies need to be formulated to reduce the use of natural gas as an input of electricity production. Such an enormous dependence can be curbed by replacing older technologies that consume significant amount of natural gas. It must be noted that the government of Bangladesh has realized the importance of conserving natural gas. In this respect, the current Awami League government has taken a much appreciated initiative to build the first nuclear power plant in Bangladesh by October 2013. Recently, after meeting with Russia's President Vladimir Putin on January 15 2013, Bangladesh's Prime Minister Sheikh Hasina has also confirmed that Russia would finance 90 percent of the plant [1]. Such initiatives that focus on alternative energy source and international cooperation are expected to conserve the consumption of natural gas.

Third, appropriate incentives for the efficient use of natural gas can ensure conservation policies. At the industrial and commercial level, regulatory authorities may provide tax incentives for the use of energy efficient renewable technologies. Building highly energy efficient industries would reduce the consumption of natural gas [40].

In many cases, upon receiving bribery, corrupt officials from the distributing authorities allow illegal usage of natural gas for domestic, industrial or commercial level. Such corrupt

procedures help users to pay less than the actual amount of usage. Through proper monitoring and laws, regulatory authority may reduce the level of corruption in energy sector. In a roundtable discussion in 2012, energy experts also underscored the importance of devising and implementing energy conservation act to ensure energy efficiency in Bangladesh [43].

Finally, the long run energy efficiency goal can be achieved by mobilizing resources in research and development (R&D) to promote efficiency not only in the natural gas sector, but also in alternative sources of energy to substitute the consumption of natural gas. A number of institutes, universities and research organizations are carrying out R&D activities on energy-efficient technologies.[5] UNESCAP [44] report identifies lack of financial support as one of the most important constraints in the R&D activities on projects related to energy efficiency. Therefore, government may allocate sufficient resources to ensure successful innovation of energy efficient techniques in the future. Overall, the success of natural gas and other energy conservatory policy will rely on efficient management, efficient production and distribution of natural gas, international cooperation, formulation and implementation of appropriate law and innovation and invention of energy efficient techniques.

6. Conclusion

While total reserves of different types of minerals, oil and coal are quite small, reserves of natural gas in Bangladesh are very large [31]. Current estimates suggest that 22 discovered gas fields have reserves of around 15 trillion cubic feet of natural gas. With the development in manufacturing and service sectors, total demand for natural gas consumption has also gone up significantly in recent years. In such a situation, it is important to identify if there is any causal relationship between the consumption of natural gas and GDP.

Our paper finds the evidence of a unidirectional causality running from GDP to natural gas consumption. In other words, movements in GDP affect the consumption of natural gas, while the reverse is not true. Therefore, the conservation hypothesis is found to be significant for Bangladesh.

Previous empirical work on Bangladesh economy found the importance of conservation policy for electricity and aggregate energy consumption. Our results reinforce the role of energy conservation policy for Bangladesh. Since the current reserves of natural gas are expected to meet the increased consumption demand for only about two decades before exhausted, it is ideal to design conservation policies without any concern of restraining the economic growth in Bangladesh.

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